ATTACHMENT B

SUBSTITUTE SPECIFICATION

(SHOWING ALL CHANGES MADE TO THE ENGLISH-LANGUAGE TRANSLATION OF THE SPECIFICATION)

METHOD FOR ~~OPTIMISING~~ OPTIMIZING PLATES IN A PLATE-LINK CHAIN, AND PLATE FOR A PLATE-LINK CHAIN

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates to a method for optimizing link plates in a plate-link chain for use in a variable speed unit of a belt-driven conical-pulley transmission. The invention furthermore relates to a link plate configuration for such a plate-link chain.

DESCRIPTION OF THE RELATED ART

Belt-driven conical-pulley transmissions with continuously variable transmission ratios are used increasingly in modern motor vehicles, not only because of the driving comfort that can be achieved with them, but also for possible fuel consumption savings.

One component that is decisive for the durability and the torque transmission ability of the variable speed unit of such a belt-driven conical-pulley transmission is the endless torque-transmitting means itself, which can be designed ~~for example~~ as a plate-link chain, for example, as illustrated diagrammatically in Fig. 5 in a small section. Such a plate-link chain is composed of plate-links 10, which are connected with each other by means of rocker members 12 ~~with each other~~. The plate-links 10 are arranged behind one another in several rows that extend in the direction of

movement of the plate-link chain and that are arranged adjacent to each other ~~with respect to the direction of motion of the plate-link chain, wherein in~~ In Fig. 5 the plate 10_1 is part of the front row in the viewing direction, the plate 10_2 is part of a row adjacent to the front row, and plate 10_3 is part of another row. To connect the plates, rocker members 12 are provided, which ~~penetrate~~ extend through the respective plate openings 14 transversely to the direction of ~~motion, respectively~~ chain movement. In doing so, two rocker member pairs 16_1 and 16_2 ~~penetrate~~ extend through each plate opening, wherein the ~~plates~~ rocker members 12_1 and 12_2 are part of the rocker member pair 16_1 and the ~~plates~~ rocker members 12_3 and 12_4 are part of the rocker member pair 16_2. As can be seen, the exterior sides of the rocker members 12_1 and 12_4, which face away from each other, of the rocker member pairs 16_1 or 16_2 are supported on the ~~inside~~ inner surface of the plate opening 14, either on the front or the rear ~~inside~~ oinner surface in relation to the direction of ~~motion~~ movement of the plate-link chain. The rocker members 12_2 and ~~12_4 which~~ 12_3 that face each other are supported on the ~~insides~~ inner surfaces of plate openings of plates arranged in adjacent rows. The surfaces of the rocker members of each rocker member pair facing each other form rolling surfaces, on which the rocker members roll against each other when the radius R, at which the respective region of the plate-link chain is curved, changes.

Such a plate-link chain, as well as the corresponding variable speed unit with two conical disk pairs, around which the plate-link chain runs, are known as such and will therefore not be described in detail.

Fig. 6 shows a plate 10 and a rocker member 12 in an enlarged scale.

The ~~rocker member 12~~ plate 10 has two longitudinal legs 18 and two vertical legs 20, which jointly enclose the plate opening 14. According to Fig. 6, the rocker member 12, the rolling surface of which has been designated with the reference number ~~20~~ 21, lies ~~on the~~ with its right side against the ~~inside~~ inner surface of the plate opening 14, wherein the contact surfaces have been adjusted with each other such that contact only occurs in the region of the transition between the longitudinal legs 18 to the vertical legs 20, and that in the region of the center of the vertical leg 20 no contact occurs between rocker member 20 and opening 14 of plate 10. When the plate 10 according to Fig. 6 is moved from right to left, forces are transmitted ~~on~~ at the contact ~~surface accordingly~~ regions through the force transmitted by the plate-link chain, as represented in the figures with the arrows F indicating the load centers of the force and the force directions. Due to the offset design of the application points of the force in relation to the center of the longitudinal legs, tensile as well as bending ~~stress~~ stresses act ~~in~~ within the longitudinal legs 18. Likewise, bending and ~~tension stress~~ tensile stresses act ~~upon~~ within the vertical legs 20.

~~By nature~~ Naturally, with given materials and given geometrical ~~framework~~ boundary conditions of the respective variable speed unit, i.e., its ~~division~~ spacing, minimal and maximum revolution radius of the plate-link chain, etc., as well as the torque to be transmitted, the dimensions required for a plate depend ~~on~~ upon the ~~stress~~ stresses that ~~is~~ are active ~~in~~ within the plate.

An object of the present invention is to design plates such that with given ~~framework~~ boundary conditions the plate is optimized with the goal of minimal material usage and hence minimal weight.

SUMMARY OF THE INVENTION

A first solution ~~of~~ to achieve that object is achieved with a method for optimizing the plates of a plate-link chain for use in a variable speed unit of a belt-driven conical-pulley transmission ~~, with said~~ . The plate-link chain ~~comprising plates~~ includes plate links arranged behind one another in several rows that are arranged next to one another transversely in relation to the direction of ~~motion~~ movement of the plate-link chain ~~, wherein said plates~~ . The plate links overlap transversely in relation to the direction of ~~motion~~ chain movement and are connected by means of rocker members ~~penetrating them~~ that extend transversely in relation to the direction of ~~motion, wherein an~~ movement of the chain. An opening of each plate is penetrated by two rocker member pairs, wherein the rocker members of ~~which~~ the rocker member pairs that face away from each other rest against the front or rear inside inner surfaces of the plate opening ~~, and the~~ . The rocker members facing each other rest against the front or rear ~~inside~~ inner surfaces of plate openings of adjacent plates ~~; wherein the~~ . The surfaces of the rocker members that face each other of each rocker member pair ~~facing one another~~ roll against each other when the plate-link chain bends~~, by which method~~ . As a result of the chain bending, the transmission of force from the rocker members into the plates occurs such that the bending stress ~~of~~ acting within the longitudinal legs ~~extending~~ that extend in the direction of ~~motion or~~ chain movement , and the bending stress acting within the vertical legs ~~extending~~ that extend perpendicular to the direction of ~~motion~~ movement of the plates resulting from the force transmission is minimized ~~in~~ for given boundary conditions.

An advantageous embodiment of the method ~~according to~~ in accordance with the invention ~~consists of~~ involves minimizing the bending moment MB of the longitudinal legs ~~for~~ of the plates of the plate-link chain ~~corresponding to~~ in accordance with the following formula ~~in~~ for given boundary conditions:

$$MB = \frac{F * He}{k+1} \bullet \left[1 - \frac{He}{L2}\right] \qquad \text{with} \qquad k = \frac{I2 * L1}{I1 * L2}, \text{ wherein}$$

F = applied force ~~introduced~~

He = lever arm of the applied force F ~~introduced~~

$I1$ = ~~surface inertial factor~~ planar moment of inertia of the longitudinal leg (= leg height^3*thickness/12)

$I2$ = ~~surface inertial factor~~ planar moment of inertia of the vertical leg (= leg width^3*thickness/12)

$L1$ = overall length of the longitudinal leg

$L2$ = overall length of the vertical leg.

The bending moment MA of the vertical legs is minimized for the plate-link chain ~~corresponding to~~ in accordance with the following formula ~~in~~ for given boundary conditions:

$$MA = F * He * \left[1 - \frac{1}{k+1} \bullet \left(1 - \frac{He}{L2}\right) - \right] \qquad \text{with} \qquad k = \frac{I2 * L1}{I1 * L2}, \text{ wherein}$$

F = applied force ~~introduced~~

He = lever arm of the applied force ~~introduced~~ F

$I1$ = ~~surface inertial factor~~ planar moment of inertia of the longitudinal leg (= leg height^3*thickness/12)

$I2$ = ~~surface inertial factor~~ planar moment of inertia of the vertical leg (= leg width^3*thickness/12)

$L1$ = overall length of the longitudinal leg

$L2$ = overall length of the vertical leg.

Another solution to the object of the invention is ~~reached~~ achieved with a plate for a plate-link chain for use in a variable speed unit of a belt-driven conical pulley transmission ~~, which~~ . The plate-link chain ~~has plates~~ includes plate links arranged behind one another in several rows that are arranged next to another transversely in relation to the direction of ~~motion~~ movement of the plate-link chain ~~, which~~ . The plate links overlap transversely in relation to the direction of ~~motion~~ chain movement and are connected by means of rocker members ~~penetrating them~~ that extend transversely in relation to the direction of ~~motion, wherein an~~ movement of the chain. An opening of each plate is penetrated by two rocker member pairs, ~~whose~~ wherein surfaces of the rocker members ~~which~~ of the rocker member pairs that face away from each other rest against the front or rear ~~inside~~ inner surfaces of the plate opening ~~and whose~~ . The surfaces of the rocker members of the rocker member pairs that face each other rest against the front or rear ~~inside~~ inner surfaces of plate openings of adjacent plates ~~, wherein the~~ The surfaces of the rocker members of each rocker member pair that face each other roll against each other when the plate-link chain bends ~~, wherein the~~ . The plate is dimensioned such that the bending stress ~~applied to~~ acting within the longitudinal legs ~~extending~~ that extend in the direction of ~~motion~~ chain movement, or the bending stress acting within the vertical legs ~~extending~~ that extend perpendicular

to the direction of ~~motion~~ movement of the plate-link chain due to the transmission of force from the rocker members, is minimal under given boundary conditions.

In an advantageous embodiment of the plate ~~according to~~ in accordance with the present invention, the bending moment MB of the longitudinal legs is minimal for the plate-link chain ~~corresponding to~~ in accordance with the following formula ~~in~~ for given boundary conditions:

$$MB = \frac{F * He}{k+1} \bullet \left[1 - \frac{He}{L2}\right] \qquad \text{with} \qquad k = \frac{I2 * L1}{I1 * L2}\text{, wherein}$$

F = applied force ~~introduced~~

He = lever arm of the applied force ~~introduced~~ F

$I1$ = ~~surface inertial factor~~ planar moment of inertia of the longitudinal leg (= leg height^3*thickness/12)

$I2$ = ~~surface inertial factor~~ planar moment of inertia of the vertical leg (= leg width^3*thickness/12)

$L1$ = overall length of the longitudinal leg

$L2$ = overall length of the vertical leg.

In another embodiment, the bending moment MA of the vertical leg is minimal for the plate-link chain corresponding to the following formula in given boundary conditions:

$$MA = F * He * \left[1 - \frac{1}{k+1} \bullet \left(1 - \frac{He}{L2}\right) - \right] \qquad \text{with} \qquad k = \frac{I2 * L1}{I1 * L2}\text{, wherein}$$

F = applied force ~~introduced~~

He = lever arm of the applied force ~~introduced~~ F

$I1$ = ~~surface inertial factor~~ planar moment of inertia of the longitudinal leg (= leg height^3*thickness/12)

$I2$ = ~~surface inertial factor~~ planar moment of inertia of the vertical leg (= leg width^3*thickness/12)

$L1$ = overall length of the longitudinal leg

$L2$ = overall length of the vertical leg.

The value for k ~~ranges~~ advantageously ranges from 1 to 3.5.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be explained below based on diagrammatic drawings for example and with additional details.

There is shown:

Fig. 1 a ~~simple model~~ simplified representation of a plate in a side view,

Fig. 2 a ~~section~~ portion of the ~~model from~~ representation of Fig. 1 to explain ~~cutting~~ sectional forces and moments,

Fig. 3 a ~~section from~~ portion of Fig. 1 to explain the course of the bending moments,

Fig. 4 a side view of a half of a conventional plate and an optimized plate,

Fig. 5 a ~~section~~ portion of a plate-link chain ~~revolving~~ as it revolves at a radius R, and

Fig. 6 a side view of a known plate with a rocker member arranged therein.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 is a simplified diagrammatic ~~illustration~~ representation of the plate ~~20~~ 10 of Fig. 6, which is represented ~~by the thick~~ as a rectangle ~~comprising~~ that includes the longitudinal legs 18 and the vertical legs 20. L1 designates the overall length of a longitudinal leg or of the longitudinal length of the plate. L2 designates the overall length of a vertical leg 20 or of the vertical height of the plate. The arrows F illustrate, as shown in Fig. 6, the ~~active~~ forces acting on the plate 10. He designates the distance of the ~~active~~ line of action of the force ~~active adjacently in relation~~ F that is adjacent to a longitudinal leg ~~to the longitudinal leg~~ , or ~~to~~ the length of the lever arm of the force F ~~referring to~~ in the direction of the longitudinal legs. ~~J2~~ J1 designates the ~~surface inertial factor~~ planar moment of inertia of the longitudinal leg, i.e., $SH^{3*}D/12$, wherein SH is the height of the longitudinal leg (see Fig. 4). The ~~surface inertial factor~~ planar moment of inertia ~~I2~~ J2 of the vertical leg is $SB^{3*}D/12$, wherein SB is the width of the ~~longitudinal~~ vertical leg (Fig. 4) and D the thickness of the plate.

Fig. 2 illustrates the observed ~~cutting~~ sectional forces and moments, wherein FA represents the force active in the vertical leg and extending in the direction of the vertical leg [[,]] . MA represents the bending moment of the vertical leg, which is caused by the force F transmitted ~~by~~ to the plate and active in the longitudinal direction of the plate-link chain ~~, and~~ , MB is the bending moment of the longitudinal leg caused by the force F. F obviously designates the ~~entire~~ total force transmitted ~~respectively by a bar~~ to a plate, of which each longitudinal leg ~~absorbs~~ receives one-half.

Fig. 3 shows the bending moments MA and MB ~~active in~~ that act on a vertical leg 20 and on the longitudinal legs 18 as a consequence of the force.

An analysis and calculation in which the bending moment progression is determined initially in sections and then in which the overall bending moment ~~overall~~ is determined is based upon the view shown in ~~the image of~~ Fig. 3. The bending moment MA in the vertical leg 20 is ~~starting~~ initially constant beginning from its center outward ~~initially constant~~ and is directed inward (-), then it decreases to zero ~~to be~~ and is directed outward (+) ~~, and~~ . The bending moment MB is constant along the entire longitudinal leg 18 and is directed outward. The ~~amount~~ magnitude of the bending moment MB in the longitudinal legs ~~results~~ is as follows:

$$MB = \frac{F * He}{k+1} \bullet \left[1 - \frac{He}{L2}\right] \qquad \text{with} \quad k = \frac{I2 * L1}{I1 * L2}$$ ~~, wherein~~

The ~~amount~~ magnitude of the bending moment MA in the vertical legs ~~results~~ is as follows:

$$MA = F * He - MB$$

$$MB = \frac{F * He}{k+1} \bullet \left[1 - \frac{He}{L2}\right]$$

and $k = \frac{I2 * L1}{I1 * L2}$

$$MA = F * He * \left[1 - \frac{1}{k+1} \bullet \left(1 - \frac{He}{L2}\right) - \right]$$

Overall, the following dependencies and influences can be determined:

The bending moment MB in the longitudinal legs is constant ~~across the~~ along their entire length L1. The influence of the lever arm He on the bending moment MB is nearly linear. When the ratio of the length of the longitudinal leg L1 to the length of the vertical leg L2 increases, the bending moment MB decreases. When the *I2/I1* ratio increases, the bending moment MB decreases as well. The ~~firmer~~ stiffer the vertical

leg is compared to the longitudinal leg, the less bending moment is transmitted into the longitudinal leg. A decrease in the height SH of the longitudinal leg causes a relatively small increase in the maximum stress ~~of~~ within the longitudinal leg (stress in its outer region). Additionally, ~~this~~ that reduces the portion of the bending stress in the maximum stress. In the range from 40% to 70% of the height of the longitudinal leg, the maximum stress remains nearly constant. The analytical observations furthermore show that the bending stress in the longitudinal leg decreases with increasing length L1 of the plate in relation to the height L2 of the plate.

Analogous dependencies apply for the bending moment MA.

When considering the respective boundary conditions, such as available ~~construction~~ design, ~~division~~ spacing of the plate-link chain, force to be transmitted etc., the above formulas enable a minimization of the bending stress, or of the bending moment MB ~~of~~ acting on the longitudinal legs 18 or of the bending moment MA ~~of~~ acting on the vertical legs 20, thus allowing the required material and hence the weight to be lowered ~~with~~ for a given force F that is to be transmitted. In order to minimize MB or MA based on the above formulas, various mathematical methods can be employed, wherein at least one of the variables is modified and its influence on MB or on MA can be examined until MB or MA overall becomes minimal under the given boundary conditions.

Of course only MA or only MB can be minimized, ~~wherein~~ whereby it is advantageous to minimize the two in a mutually adjusted fashion.

Fig. 4 shows the result of an optimization, in which the ~~division~~ distance T (the distance between the rocker surfaces of adjacent rocker member pairs), the length L1,

the thickness of the rocker member and the force to be transmitted have been kept constant. ~~DM~~ DW indicates the effective diameter of a bearing formed by a rocker member pair. The innermost contour line and the outermost contour line show the starting contour of a rocker member. The hatched ~~area~~ region shows the contour of an optimized rocker member. As is evident, the height of the longitudinal leg was clearly reduced without negatively influencing the force transmission ability of the rocker member ~~negatively~~.

The material savings evident from Fig. 4 have the additional advantage that the plate-link chain is suited for higher rotational speeds, since centrifugal forces are reduced.

The following table shows examples of advantageous ranges:

Component	Meaningful Tendency for $k_{minimal}$	1.1 Advantageous Range of Values
$I1 = (BH1^3)*T/12$	BH1 as small as possible	2.4 < BH1 < 3.0
$I2 = (BB2^3)*T/12$	BB2 as large as possible	2.7 < BB2 < 3.0
L1	L1 as large as possible	Maximum 20.5 mm
L2	L2 as small as possible	11.6 < L2 < 13

The factor k advantageously lies between 1 and 3.5.

~~Due to~~ Because of the optimized bending ~~stress of~~ stresses within the longitudinal and vertical legs ~~according to~~ in accordance with the invention, it is possible to accommodate in a small space plate-link chains with increased force and/or torque transmission ~~ability~~ capability, thus reducing the overall spatial requirement of the variable speed unit. ~~This~~ That result is achieved above all with an

optimized ratio between the dimensions of L1 and L2 and the ~~factors~~ moments of inertia I1 and I2.

The patent claims submitted with the application are formulation proposals without prejudice for achieving farther-reaching patent protection. The applicant reserves the right to claim additional feature combinations that have so far only ~~be~~ been disclosed in the description and/or drawings.

References used in the dependent claims point to the further development of the object of the main claim by features of the respective dependent ~~claim~~ claims. They should not be interpreted as a waiver for obtaining independent, object-related protection for the feature combinations of the referenced dependent claims.

Since the objects of the dependent claims with respect to the state of the art can form their own and independent inventions ~~on~~ as of the priority date, the applicant reserves the right to make them the object of independent claims or declarations of division. They can furthermore also turn into independent inventions, having a form that is independent from the objects of the preceding dependent claims.

The embodiments should not be interpreted as a limitation of the invention. Rather, within the framework of the present disclosure, numerous changes and modifications are possible, especially such variations, elements, and combinations and/or materials that are obvious to those skilled in the art with respect to the solution of the task at hand, for example by combining or modifying individual features and/or elements or procedural steps described in connection with the general description and embodiments, as well as those contained in the drawings and that lead to a novel object or new procedural steps or procedural step sequences through features that

can be combined, also to the extent that they relate to manufacturing, testing, and operating methods.

~~**Patent Claims**~~

What is claimed is: